CLAIMS

What is claimed is:

1. (Cancelled) .

2. (Currently Amended) The vision-based identification apparatus of claim ~~1~~ **3**, wherein the image capture device is a video camera responsive to electromagnetic radiation substantially in at least one of the regions selected from the group consisting of the visible region, and the infrared region.

3. (Currently Amended) ~~The vision-based identification apparatus of claim 1,~~ A vision-based identification apparatus comprising:

a host vehicle;

wherein said host vehicle is equipped with a plurality of elements including:

i) an image capture device element; operatively interconnected with;

ii) an image signal processor element; which is operatively interconnected with;

iii) a matching processor element; which is also operatively interconnected with;

iv) a radar transceiver element;

wherein the image capture device element is configured to provide a time-based sequence of data frames to the image signal processor element and the image signal processor element provides a processed image signal to the matching processor element, and wherein the data frames include a two-dimensional array of pixel elements; and wherein the radar transceiver element is configured to provide a radar signal to the matching processor element, and

wherein the matching processor element combines the processed image signal and the radar signal, whereby the combined signals complement each other and allow the apparatus to effectively identify objects likely to be misidentified as collision threats, wherein the time-based sequence of data frames include a plurality of data elements including at least one horizontal edge; and

wherein each horizontal edge is identified based on a plurality of pixels having a substantially similar electromagnetic radiation response across a plurality of substantially horizontally aligned pixels; and

wherein the image signal processor element extracts horizontal edges, from the time-based sequence of data frames, in the form of edge pixels, and

wherein the edge pixels are projected in each row of the data frames, to get a horizontal edge projection in the sequence of data frames; and

wherein each horizontal edge projection may be tracked in time based on the horizontal edge projection's sequential appearance in the data frames.

4. (Original) The vision-based identification apparatus of claim **3**, wherein horizontal edge projections may be tracked in time by recording sequential data frames and matching horizontal edge projections in the sequential data frames while allowing, in the sequential data frames, for minor variations from, in at least one of the following categories:

i. the relative position of the horizontal edge projection in the frame;

ii. the relative orientation of the horizontal edge projection in the frame; and

iii. the relative length of the horizontal edge projection; and

wherein at least one new tracking sequence can exist for horizontal edge projections that have predefined characteristics but were not present in prior data frames.

5. (Original) The vision-based identification apparatus of claim **4**, wherein allowed, minor variations in the sequential data frames provide data that allows for the determination and recordation of distance traveled since the beginning of each horizontal edge projection tracking sequence, and

wherein horizontal edge projection tracks are sorted based on at least one of the following;

i) the duration of image inputs that the horizontal edge projection track records,

ii) the average length of the horizontal edge projection, and

iii) whether the horizontal edge projection track at current image frame is in an updating mode, a non-updating mode, or is a new horizontal edge projection.

6. (Original) The vision-based identification apparatus of claim **4** wherein the horizontal edge projection tracks are compared with predetermined parameters to determine if tracking possibilities exist;

if tracking possibilities exist then the vision-based identification apparatus is utilized to track substantially horizontal edges through successive image inputs.

7. (Original) The vision-based identification apparatus of claim **6** wherein the predetermined parameters include at least one of the following;

i. the number of successive image inputs having horizontal edge projection tracks, and

ii. the magnitude of the horizontal edge projection tracks.

8. (Original) The vision-based identification apparatus of claim **4** wherein if no tracking possibilities exist, tracking may still occur for a pre-specified number of image inputs without tracking possibilities before the tracked horizontal edge projection track is discarded.

9. (Currently Amended) The vision-based identification apparatus of claim ~~1~~ 3 wherein tracking of horizontal edge projection vectors is assisted by using at least one of the following:

i) vertical motion compensation;

ii) forward motion compensation;

wherein vertical motion compensation helps predict where tracked horizontal edge projection vectors will be located on successive image inputs by compensating for vertical motion, and

wherein the forward motion compensation helps predict where tracked horizontal edge projection vectors will be located on successive image inputs by compensating for forward motion.

10. (Original) The vision-based identification apparatus of claim **9** wherein forward motion compensation is achieved by using at least two previous points from the image

input on the tracked horizontal edge projection tracks, immediately before the image input that requires forward motion compensation for tracked horizontal edge projection vectors location prediction.

11. (Original) The vision-based identification apparatus of claim **9** wherein vertical motion is determined by:

i. extracting vertical slices of the image input; and

ii. extracting one dimensional optical flow profiles of relative intensity of the vertical slices; and

iii. averaging the optical flow of all vertical slices.

12. (Original) The vision-based identification apparatus of claim **11** wherein the vertical slices are extracted from each image input, and

the relative extreme negative intensities relate to a change from light to dark of an apparent horizon.

13. (Original) The vision-based identification apparatus of claim **11** wherein the extreme negative intensities' average variation between rows on successive image inputs is an indicia of how an image collection device is moving vertically relative to at least one of the following:

i. an apparent horizon; and

ii. a distinct feature in the distance.

14. (Currently Amended) The vision-based identification apparatus of claim ~~1~~ 3 wherein the signal input from the image capture device to the image signal processor is a single horizontally centered window of the image signal input from the image capture device.

15. (Original) The vision-based identification apparatus of claim **14** wherein the single horizontally centered window is set at a predetermined width and a predetermined height and

wherein the single horizontally centered window can be adjusted either left or right based on steering wheel position, or lane information.

16. (Original) The vision-based identification apparatus of claim **14** wherein successive horizontal edge projection tracks have a length in excess of a predetermined length.

17. (Original) The vision-based identification apparatus of claim **14** wherein if no tracking possibilities exist, a tracking protocol will be allowed to remain in operation for a pre-specified number of image inputs without tracking possibilities before the tracked horizontal edge projection track is discarded.

18. (Cancelled)

19. (Currently Amended) A vision-based identification method as set forth in claim ~~18~~ **20**, wherein the image capture device element is a video camera responsive to

electromagnetic radiation substantially in at least one of the regions selected from the group consisting of the visible region, and the infrared region.

20. (Currently Amended) ~~A vision-based identification method as set forth in claim 18~~ A vision-based identification method comprising the steps of:

providing a host vehicle; and

equipping the host vehicle with a plurality of elements including:

i) an image capture device element; operatively interconnected with;

ii) an image signal processor element; which is operatively interconnected with;

iii) a matching processor element; which is also operatively interconnected with;

iv) a radar transceiver element;

wherein the image capture device element is configured to provide a time-based sequence of data frames to the image signal processor element and the image signal processor element provides a processed image signal to the matching processor element; and wherein the data frames include a two dimensional array of pixel elements; and wherein the radar transceiver element is configured to provide a radar signal to the matching processor element; and

wherein the matching processor element combines the processed image signal and the radar signal, whereby the combined signals complement each other and allow for the effective identification of objects likely to be misidentified as collision threats, wherein the time-based sequence of data frames include a plurality of data elements including at least one horizontal edge; and

wherein each horizontal edge is identified based on a plurality of pixels having a substantially similar electromagnetic radiation response across a plurality of substantially horizontally aligned pixels; and

wherein the image signal processor element extracts horizontal edges, from the time-based sequence of data frames, in the form of edge pixels; and

wherein the edge pixels are projected in each row of the data frames, to get a horizontal edge projection in the sequence of data frames; and

wherein each horizontal edge projection may be tracked in time based on the horizontal edge projection's sequential appearance in the data frames.

21. (Original) A vision-based identification method as set forth in claim **20**, wherein horizontal edge projections may be tracked in time by recording sequential data frames and matching horizontal edge projections in the sequential data frames while allowing, in the sequential data frames, for minor variations from, in at least one of the following categories:

i. the relative position of the horizontal edge projection in the frame;

ii. the relative orientation of the horizontal edge projection in the frame; and

iii. the relative length of the horizontal edge projection; and

wherein at least one new tracking sequence can exist for horizontal edge projections that have predefined characteristics but were not present in prior data frames.

22. (Original) A vision-based identification method as set forth claim **21**, wherein allowed, minor variations in the sequential data frames provide data that allows for the

determination and recordation of distance traveled since the beginning of each horizontal edge projection tracking sequence, and

wherein horizontal edge projection tracks are sorted based on at least one of the following;

i. the duration of image inputs that the horizontal edge projection track records;

ii. the average length of the horizontal edge projection; and

iii. whether the horizontal edge projection track at current image frame is in an updating mode, a non-updating mode, or is a new horizontal edge projection.

23. (Original) A vision-based identification method as set forth in claim **21** wherein the horizontal edge projection tracks are compared with predetermined parameters to determine if tracking possibilities exist;

if tracking possibilities exist then the vision-based identification apparatus is utilized to track substantially horizontal edges through successive image inputs.

24. (Original) A vision-based identification method as set forth in claim **23** wherein the predetermined parameters include at least one of the following;

i. the number of successive image inputs having horizontal edge projection tracks; and

ii. the magnitude of the horizontal edge projection tracks.

25. (Original) A vision-based identification method as set forth in claim **21** wherein if no tracking possibilities exist, tracking may still occur for a pre-specified number of image

inputs without tracking possibilities before the tracked horizontal edge projection track is discarded.

26. (Currently Amended) The vision-based identification method of claim ~~18~~ 20 wherein tracking of horizontal edge projection vectors is assisted by using at least one of the following:

i) vertical motion compensation; and

ii) forward motion compensation;

wherein vertical motion compensation helps predict where tracked horizontal edge projection vectors will be located on successive image inputs by compensating for vertical motion, and

wherein the forward motion compensation helps predict where tracked horizontal edge projection vectors will be located on successive image inputs by compensating for forward motion.

27. (Original) The vision-based identification method of claim **26**, wherein forward motion compensation is achieved by using at least two previous points from at the image input on the tracked horizontal edge projection tracks, immediately before the image input that requires forward motion compensation for tracked horizontal edge projection vectors location prediction.

28. (Original) A vision-based identification method as set forth in claim **26**, wherein vertical motion is determined by:

i. extracting vertical slices of the image input; and

ii. extracting one dimensional optical flow profiles of relative intensity of the vertical slices; and

iii. averaging the optical flow of all vertical slices.

29. (Original) A vision-based identification method as set forth in claim **28**, wherein the vertical slices are extracted from each image input, and

the relative extreme negative intensities relate to a change from an electromagnetic radiation emission region having a greater intensity to an electromagnetic radiation emission region of lower intensity of an apparent horizon.

30. (Original) A vision-based identification method as set forth in claim **28**, wherein the extreme negative intensities' average variation between rows on successive image inputs is an indicia of how an image collection device is moving vertically relative to at least one of the following:

i. an apparent horizon; and

ii. a distinct feature in the distance.

31. (Currently Amended) A vision-based identification method as set forth in claim <u>20</u> ~~**18**~~, wherein the signal input from the image capture device to the image signal processor is a single horizontally centered window of the image signal input from the image capture device.

32. (Original) A vision-based identification method as set forth in claim **31**, wherein the single horizontally centered window is set at a predetermined width and a predetermined height; and

wherein the single horizontally centered window can be adjusted either left or right based on steering wheel position, or lane information.

33. (Original) A vision-based identification method as set forth in claim **31**, wherein successive horizontal edge projection tracks have a length in excess of a predetermined length.

34. (Original) A vision-based identification method as set forth in claim **31** wherein if no tracking possibilities exist, a tracking protocol will be allowed to remain in operation for a pre-specified number of image inputs without tracking possibilities before the tracked horizontal edge projection track is discarded.

35. (New) An identification method comprising acts of:

receiving an input image sequence;

isolating stationary objects from the input image sequence, wherein the act of isolating further includes acts of:

generating a horizontal edge projection from the input image sequence;

estimating a vertical motion from the input image sequence;

estimating an object parameter of the stationary objects from the horizontal edge projection and the vertical motion;

receiving a radar signal;

classifying objects within the radar image as moving or non-moving objects; and

comparing the non-moving objects from the radar image with the object parameter of the stationary objects, wherein non-moving objects outside of a given object parameter are classified as a non-threat, and non-moving objects within a given object parameter are classified as a threat.

36. (New) The method of Claim 35, wherein the act of estimating an object parameter further includes an act of estimating a distance to and a height of the stationary object.

37. (New) The method of Claim 36, wherein the act of isolating stationary objects further comprises an act of isolating overhead stationary objects.

38. (New) The method of Claim 36, the act of estimating a distance to and a height of the stationary object further comprises acts of:

establishing a horizontal edge projection track from the horizontal edge projection;

calculating a first coordinate of the horizontal edge projection track y_i utilizing a first equation

$y_i = \frac{fH}{Z_i}$, where i=0, ..., N-1, H is the height of the stationary object above a predetermined point, Z_i is the distance of the stationary object to the predetermined point at frame i, and N is the number of points in the horizontal edge projection track;

calculating y_i using a second equation

$y_i = Y_0 - r_i$, where r_i is a location of the horizontal edge projection track for frame i, and Y_0 is a reference horizon;

calculating Z_i utilizing a third equation

$Z_i = D - d_i$, where D is a distance between the stationary object and the predetermined point when i=0 and d_i is the distance the predetermined point has traveled from i=0 to i=i;

substituting the second equation and the third equation into the first equation resulting in a fourth equation

$(Y_0 - r_i)D - fH = (Y_0 - r_i)d_i$, where i=0, ..., N-1

rewriting the fourth equation as a matrix A, where the matrix A (N by 2) and a column vector B (size N) are made up of the coefficients in the fourth equation,

$$A\begin{pmatrix} D \\ H \end{pmatrix} = B$$

$$A = \left[(a_0),(a_1),\ldots,(a_{n-1})\right]^T \quad a_i = [Y_0 - r_i - f]^T = [y_i, f]^T, \quad i = 0,\ldots,N-1$$

$$B = [b_0, b_1, \ldots, b_{-1}]^T \quad b_i = (Y_0 - r_i)d_i = y_i d_i, \quad i = 0,\ldots,N-1$$

solve matrix A for D and H using a least-squares method.

39. (New) The method of Claim 38, wherein the act of isolating stationary objects further comprises an act of isolating overhead stationary objects.

40. (New) An identification system comprising:

a host vehicle, wherein the host vehicle comprises:

an image capture device, operatively interconnected with;

an image signal processor, operatively interconnected with;

a matching processor, operatively interconnected with;

a radar transceiver,

wherein when the image capture device receives an input image sequence, the image signal processor isolates stationary objects from the input image sequence and provides an object parameter, the radar transceiver classifies objects within the radar image as moving or non-moving objects, and the matching processor compares the non-moving objects with the object parameter, wherein non-moving objects outside of a given parameter are classified as a non threat, and non-moving objects within a given object parameter are classified as a threat.

41. (New) The system of Claim 40, wherein the object parameter is distance and height of the stationary object.

42. (New) The system of Claim 40, wherein stationary objects are overhead stationary objects.

43. (New) The system of Claim 40, wherein the matching processor has computer further instructions for performing the operations of:

establishing a horizontal edge projection track from the horizontal edge projection;

calculating a first coordinate of the horizontal edge projection track y_i utilizing a first equation

$y_i = \frac{fH}{Z_i}$, where i=0, …, N-1, H is the height of the stationary object above a predetermined point, Z_i is the distance of the stationary object to the predetermined point at frame i, and N is the number of points in the horizontal edge projection track;

calculating y_i using a second equation

$y_i = Y_0 - r_i$, where r_i is a location of the horizontal edge projection track for frame i, and Y_0 is a reference horizon;

calculating Z_i utilizing a third equation

$Z_i = D - d_i$, where D is a distance between the stationary object and the predetermined point when i=0 and d_i is the distance the predetermined point has traveled from i=0 to i=i;

substituting the second equation and the third equation into the first equation resulting in a fourth equation

$(Y_0 - r_i)D - fH = (Y_0 - r_i)d_i$, where i=0, …, N-1

rewriting the fourth equation as a matrix A, where the matrix A (N by 2) and a column vector B (size N) are made up of the coefficients in the fourth equation,

$$A\begin{pmatrix} D \\ H \end{pmatrix} = B$$

$$A = [(a_0),(a_1),\ldots,(a_{n-1})]^T \quad a_i = [Y_0 - r_i - f]^T = [y_i, f]^T, \quad i = 0,\ldots,N-1$$

$$B = [b_0, b_1,\ldots,b_{-1}]^T \quad b_i = (Y_0 - r_i)d_i = y_i d_i, \quad i = 0,\ldots,N-1$$

solve matrix A for D and H using a least-squares method.

44. (New) The method of Claim 43, wherein the stationary objects are overhead stationary objects.